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Impact of Modern Agriculture Practices on Soil Quality and Edaphic Ecosystem

Abstract

Agricultural practices and use of chemicals releases residuals that may degrade the quality of agriculture soil. The magnitude of soil degradation is not difficult to assess due to its point source nature. Maximum use of chemical fertilizers, pesticides is creating problem not only to water resources but also to soil biota, food grain quality and soil quality also. The present paper emphasizes on the current situation of soil quality and soil ecosystem affected by agricultural practices.

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Introduction

The history of agriculture in India dates back to Indus Valley Civilization Era and even before that in some parts of Southern India. Today, India ranks second worldwide in farm output. Agriculture and allied sectors like forestry and fisheries accounted for 13.7% of the GDP (gross domestic product) in 2013, about 50% of the workforce. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth (IBEF, 2016).

Vedic literature provides some of the earliest written record of agriculture in India. Rigveda hymns, for example describes plowing, fallowing, irrigation, fruit and vegetable cultivation. Other historical evidence suggests rice and cotton were cultivated in the Indus Valley, and plowing patterns from the Bronze Age have been excavated at Kalibangan in Rajasthan. Bhumivargaha, an Indian Sanskrit text, suggested to be 2500 years old, classifies agricultural land into 12 categories: urvara (fertile), ushara (barren), maru (desert), aprahata (fallow), shadvala (grassy), pankikala (muddy), jalaprayah (watery), kachchaha (contiguous to water), sharkara (full of pebbles and pieces of limestone), sharkaravati (sandy), nadimatruka (watered from a river), and devamatruka (rainfed) (PBS, 2016).

The world's soils are like blankets that cover most of the earth's land surfaces. One could not survive without it since most crops would not be able to grow in the dense rock that lies underneath. There is no uniform depth to our earth's soils. While it can be absent in places of exposed bedrock, soil may extend up to tens of meters into the earth's surface. Although this may not seem insignificant when compared to the depth to the core of the earth, the soil profile can be very intricate and diverse.

Maximum of the scientific literature on agricultural impacts on various environmental components is from developed countries, reflecting broad scientific concern and, in some cases, regulatory attention since the 1970s. The scientific findings and management principles are, however, generally applicable worldwide. Scientists have developed methods to describe the various components and characteristics of the soil ecosystem. By using common terminology, soil ecosystem descriptions are valuable for deciding how the soil might be used and predicting how the soil might react to its intended use. Technical descriptions of the soil are not only useful for farmers, but for scientists, ecologists, soil engineers, hydrologists and land use planners.

Aim of the study

The objective of this study is to highlight the various activities in agriculture sector and to identify their possible impacts on soil quality and soil ecosystem along with some suggestions to manage or minimize the pollution related problems.

Methodology

Secondary data was collected from different governmental agencies as well as some Non-Governmental Organizations (NGOs). Relevant data was collected and analyzed to evaluate and find out the impact of agricultural activities on agricultural soil quality and soil eco system.

Agriculture Practices

India is the world's second or third largest producer of several dry fruits, agriculture-based textile raw materials, roots and tuber crops, pulses, farmed fish, eggs, coconut, sugarcane and numerous vegetables. India ranked in the world's five largest producers of over 80% of agricultural produce items, including many cash crops such as coffee and cotton, in 2010. India is one of the world's five largest producers of livestock and poultry meat, with one of the fastest growth rates, as of 2011 (FAO, 2010).

Uttar Pradesh is the largest state of the country in terms of population and second largest in area in the country. The reporting area of the state is 24.2 million ha, out of which cultivated area is 16.68 million ha. The gross cropped area is 25.5 million ha. The cropping intensity in the state is 153 percent. Farming community is dominated by small and marginal farmers. Average size of holding is only 0.83 ha per farmer. However, the average size of holding of marginal farmers is 0.40 hectare only. The state accounts for 11 per cent India's net sown area and contributes more than 41.1 million tonnes of food-grain which is about 20 percent of the total food-grain production of the country. The state produces 38 percent of India's Wheat, 20 percent of Paddy, 21 percent of Sugarcane, 34 percent of Groundnut, 17.5 percent of Rape-seed, 8 percent of Fruits and 16 percent of Vegetables. Uttar Pradesh is the largest potato producer in the country, contributing 43 per cent of the total production. The state is the largest milk producing state of the country with an annual milk production of 11.7 million kilo litres accounting for 16 percent of total milk production of the country. Keeping in view of vast potential, the state has major role to play in ushering in farm sector led economic growth of the country (SAP, 2008).

Land use Pattern

Before spelling out the relationship between population growth and land use, it appears appropriate to discuss about the land use data. The collection of land use data in India begins at the village level. Out of the total geographical area of 328 million hectares, the land use statistics were available for roughly 284 million hectares in 1950-51; however, in 1999-2000 the reporting area is around 306 million hectares. The area, for which data on the land use classification are available; is known as the reporting area.

Area under forests includes all lands classed as forest under any legal enactment dealing with forests or administered as forest, whether state-owned or private, and whether wooded or maintained as potential forest land. The area of crops rose in the forest and grassing lands or areas open for grassing within the forests are also included under the forest area.

Table -1

Extent of Area under Various Land Uses at two intervals (in Million ha.)

Category	1980-81	2009-10	Change
Net Sown Area	140.29	140.02	-0.27
Fallow land other than current fallows	9.72	10.48	+0.76
Current fallows	14.83	15.75	-0.92
Culturable waste land	16.74	12.86	-3.88
Land under miscellaneous tree crops	3.58	3.35	-0.23
Total cultivable /culturable land	185.16	182.47	-2.69
Per capita availability of land in ha.	0.27	0.13	-0.14
Land under Non- agricultural uses	21.30	26.17	+4.87
Barren and unculturable land	19.96	16.78	-3.18
Forests	67.46	70.04	+2.58

Source: Pandey (2012)

Soil Profile

The world's soils are like blankets that cover most of the earth's land surfaces. We could not survive without it since most crops would not be able to grow in the dense rock that lies underneath. There is no uniform depth to our earth's soils. While it can be absent in places of exposed bedrock, soil may extend up to tens of meters into the earth's surface. Although this may not seem insignificant when compared to the depth to the core of the earth, the soil profile can be very intricate and diverse. In fact, the soil profile is made up of distinct layers, known as horizons (Chauhan and Bharti, 2015).

Six master soil horizons are commonly recognized and are designated using the capital letters O, A, E, B, C, and R. The following horizons are listed by their position from top to bottom within the soil profile. Not all of these layers are present in every location. For instance, P horizons only form in areas which have been waterlogged for long periods of time. Soils with a history of human interference, for instance through major earthworks or regular deep ploughing, may lack distinct horizons almost completely (Bharti et al, 2014). When examining soils in the field, attention must be paid to the local geomorphology and the historical uses to which the land has been put in order to ensure that the appropriate names are applied to the observed horizons. The horizon not listed is the O horizon which is grass and animal/plant life.

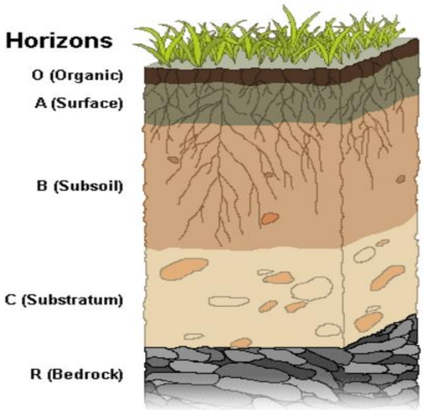

Fig.: Showing Soil Profile

Sources of Soil Pollution

Soil pollution is the major part of land degradation and chiefly is caused by the presence of human-made chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste (Malik and Bharti, 2007). The most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons (i.e. naphthalene and benzo(a)pyrene), solvents, pesticides, lead, and other heavy metals (Bharti, 2013). Soil contamination is correlated with the degree of industrialization and intensity of chemical usage in industry as well as agriculture fields (Bharti et al, 2013a; 2013b).

Impact of Soil Pollution

Soil Properties and texture

Soil texture and soil structure are both unique properties of the soil that will have a profound effect on the behavior of soils, such as water holding capacity, nutrient retention and supply, drainage, and nutrient leaching. Soil texture is the relative proportions of sand, silt, or clay in a soil. The soil textural class is a grouping of soils based upon these relative proportions. Soils with the finest texture are called clay soils, while soils with the coarsest texture are called sands. However, a soil that has a relatively even mixture of sand, silt, and clay and exhibits the properties from each separate is called a loam. Agriculture practices may alter the physical properties of soil.

Nutrients

Soil is a major source of nutrients needed by plants for growth. The three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Together they make up the trio known as NPK. Other important nutrients are calcium, magnesium and sulfur. Plants also need small quantities of iron, manganese, zinc, copper, boron and molybdenum, known as trace elements because only traces are needed by the plant. The role these nutrients play in plant growth is complex and can be changed by agricultural practices.

Soil biota

Extensive use of heavy advanced tools in tilling the agriculture fields is responsible for the destruction of useful biota of soil ecosystem. Rotavator plough is destroying the earthworms and many small useful organisms in agriculture fields. It must be taken seriously and must think for the conservation of soil biota in a sustainable manner.

Fertility

In soil fertility, coarser soils generally have a lesser ability to hold and retain nutrients than finer soils. However, this ability is reduced as finely-textured soils undergo intense leaching in moist environments.

Soil fertility and crop productivity may influence tremendously, if the improper activities will be continued. Thus, it is time to act for the survival of human beings and sustainable agriculture growth with chemical free lifestyle.

Possible Solution

Crop Rotation

Crop rotation is the practice of growing a series of dissimilar or different types of crops in the same area in sequenced seasons. It is done so that the soil of farms is not used to only one type of nutrient. It helps in reducing soil erosion and increases soil fertility and crop yield.

Organic Farming

Agriculture fields must be free from chemical fertilizers and toxic pesticides. These chemicals must be replaced with appropriate and suitable green manure, vermicompost, useful microbial consortia, and associated technologies. It will encourage the organic farming to produce healthy food for human beings.

Integrated Pest Management

Integrated pest management (IPM) is a broad-based approach that integrates practices for economic control of pests. IPM aims to suppress pest populations below the economic injury level (EIL). The UN's Food and Agriculture Organisation defines IPM as 'the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms.' IPM is used in agriculture, horticulture, human habitations, preventive conservation and general pest control, including structural pest management, turf pest management and ornamental pest management.

Eco-Friendly Tools

Eco-friendly tools must be used in the agriculture sector. A few advanced tools are creating harmful impacts on agriculture soil ecosystem by destroying useful biota of agriculture fields. Hence, the advanced tools must be optimizing to the certain extent that these are eco-friendly for agriculture ecosystem.

Cleanup

Cleanup or environmental remediation is analyzed by environmental scientists who utilize field measurement of soil chemicals and also apply computer models for analyzing transport and fate of soil chemicals. Various technologies have been developed for remediation of oil-contaminated soils.

There are several principal strategies for remediation:

1. Bioremediation, involving microbial digestion of certain organic chemicals. Techniques used in bioremediation include land farming, bio-stimulation and bio-augmentating soil biota with commercially available micro-flora.
2. Excavate soil and take it to a disposal site away from ready pathways for human or sensitive ecosystem contact. This technique also applies to dredging of bay muds containing toxins.
3. Aeration of soils at the contaminated site (with attendant risk of creating air pollution)
4. Thermal remediation by introduction of heat to raise subsurface temperatures sufficiently high to volatize chemical contaminants out of the soil for vapour extraction. Technologies include ISTD, electrical resistance heating (ERH), etc.
5. Extraction of groundwater or soil vapor with an active electromechanical system, with subsequent stripping of the contaminants from the extract.
6. Phyto-remediation, or using plants (such as willow) to extract heavy metals
7. Myco- remediation, or using fungus to metabolize contaminants and accumulate heavy metals.
8. Containment of the soil contaminants (such as by capping or paving over in place).

Suggestions by agricultural scientists for control of agricultural pollution can be at various scales. At the field level, decisions are influenced by very local factors such as crop type and land use management techniques, including use of fertilizers and pesticides. These decisions are based on best management practices that are possible under the local circumstances and are meant to maximize economic return to the farmer while safeguarding the environment. Local decisions are made on the basis of known relationships between farm practice and environmental degradation but do not usually involve specific assessment of farm practices within the larger context of river basin impacts from other types of sources. Decisions regarding use of waste water, sludges, etc., for agricultural application are also made using general knowledge of known impacts and of measures to mitigate or minimize these impacts (Ongley, 1996).

Farmers can take many steps to reduce loadings of agricultural pollutants to agriculture soil. Both structural and management practices are available for managing chemical inputs more efficiently, or by controlling runoff. Practices include integrated pest management, comprehensive nutrient management planning, irrigation water management, animal waste management, conservation tillage, and vegetative buffers (Ezeaku and Bharti, 2015).

Chemical fertilizers, pesticides and old agriculture practices are the important sources of sediment, nutrients, pesticides contamination, salts, and pathogens. The presence of these materials in soil can impose costs on whole agriculture ecosystem. Some estimates of the cost to soil pollution have been made, but overall, an accounting of the economic damages caused by contaminated soil is lacking, due to a lack of physical monitoring and the difficulties in estimating economic costs and benefits for environmental goods and services. Hence, agricultural soil must be conserved due to the chemical fertilizers/pesticides, poor agriculture practices and it can be somehow controlled by using green technology, sustainable agriculture practices or management in the Indian agriculture sector.

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Conclusion

Chemical fertilizers, pesticides and old agriculture practices are the important sources of sediment, nutrients, pesticides contamination, salts, and pathogens. The presence of these materials in soil can impose costs on whole agriculture ecosystem. Some estimates of the cost to soil pollution have been made, but overall, an accounting of the economic damages caused by contaminated soil is lacking, due to a lack of physical monitoring and the difficulties in estimating economic costs and benefits for environmental goods and services. Hence, agricultural soil must be conserved due to the chemical fertilizers/pesticides, poor agriculture practices and it can be somehow controlled by using green technology, sustainable agriculture practices or management in the Indian agriculture sector.

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